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# Study Manual for Enterprise Risk Management

by

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Thank you for purchasing the ACTEX ERM Study Manual.

Actuaries have practiced risk management for centuries. Yet it was not until recently that the actuarial profession (and indeed, the financial services industry) began to focus on risk in the context of the entire enterprise. Commercial banks started the shift a decade or so before the insurance industry, although some of their early efforts would be more aptly described as management of portfolio risk rather than enterprise risk.

The Society of Actuaries introduced the ERM exam into its syllabus in 2012. The syllabus has undergone considerable change over the last few years. This is reflective of the changes in the practice and new emerging research in what is a relatively young field. In addition, the financial crisis of 2008-2009 has spurred numerous changes in the regulatory and rating agencies perspective on risk management. The SOA has endeavored to include current publications and research in place of older papers as appropriate.

One consequence of the dynamic state of the practice and the multitude of papers included in the syllabus is a considerable amount of overlap and duplication in content. In some cases the duplication serves to fill in background for the principle subject of the paper, and in other cases it is simply the result of a different author offering his or her own perspective. In producing these study guides we have reduced some duplication but more often tended towards keeping close to the content as presented by each author.

These study guides attempt to capture the key essence of the syllabus in a considerably compressed form. They are not, however, a substitute for the original syllabus material. We recommend you start with a thorough reading of the each syllabus resource before reading the corresponding guide. Our intent is for the guides serve as an efficient means of subsequent review and overview of the entire syllabus.

Finally, I welcome any comments, observations or recommendations for improvement to this Manual.

Godspeed with your preparation for the exam.

Zafar Rashid

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# Credit Risk Management – Jorion Ch. 18

Reviewer's note: *This is a new resource for 2020. It is a simple overview of the management of credit risk in portfolios using VAR with some good numerical examples that are worth reviewing. Modeling credit risk in portfolios is a more complicated exercise than market risk and the methodologies are still evolving.*

## I. The Nature of Credit Risk

**A.** Definition: The risk of financial loss resulting from a counterparty's failure to meet its contractual obligations

**B.** Three primary risk factors:

1. Default risk measured by the probability of default (PD)
2. Credit exposure risk is the risk of fluctuations in market value and becomes exposure to default (EAD) when default happens
3. Recovery risk is the fluctuation in recovery value = (1- LGD)

**C.** Credit risk is impacted by all three of these risk factors and has a longer time horizon than market risk

**D.** Risk limits apply to the entire exposure to each legal entity and the prevailing legal issues such as bankruptcy laws are important considerations

**E.** Has an asymmetric risk profile (small upside, large downside) like a short option

1. Must have a net claim against the counterparty when the default happens
2. Credit exposure of derivative contracts exists only if the contract is "in the money"

**F.** Portfolio effects must be considered

1. Transactions with different counterparties may offset each other for market risk but credit exposure exists to each
2. Instead of adding up the separate exposures, a portfolio approach takes into account the interactions between market movements in determining the potential loss and reflects correlations in defaults

## II. Default and Recovery Risk

**A.** Default probabilities can be assessed by two methods

1. Actuarial models such as Altman z-score or credit-rating agency models
2. Market price-based models

**B.** Marginal default rates $d_i$ can be derived from the cumulative default rates $c_n$ from the typical rating agency table by recursively solving $(1-c_n)=\prod_{1}^{n}(1-d_i)$ where $c_n$ is the cumulative default rate

**C.** Market based models can be used for firms that have liquid publicly traded debt and essentially incorporate the market expectations of potential default losses

1. The firm's equity is a call option on the value of the firm's assets with a strike price equal to the face value of its debt (Merton 1974)
2. This gives the risk-neutral default probability and assumes investors do not require a risk premium
3. Credit-sensitive debt has some systematic risk and is also impacted by liquidity risk and tax effects that must be recognized in the modeling

**D.** Recovery rates f are an important component of the computation and have their own means and variation

1. They can differ depending on the seniority of the instrument, the quality of collateral, industry and the legal environment

**E.** Default correlations can't be measured directly so we have to use causative models using observable financial variables as inputs to derive the probabilities and correlations

1. In the example, the market value of the firm's assets V is modeled via simulations, a joint standard normal distribution is assumed with correlation = 0.20 to simulate the value of the assets of the each firm and for each simulation the default condition of each firm is determined. The correlation between the default condition for the two firms can be computed

## III. Credit Exposure

**A.** Credit exposure (CE) is defined as the replacement value of the asset, if positive, on the target date

1. CE = principal for debt instruments
2. CE = positive value of the contract for derivatives (much less than the notional amount)
   a. Becomes zero at maturity for some derivatives like interest rate swaps, not so for currency swaps
   b. Over long horizons, CE is impacted by a combination of amortization and diffusion effects
3. Expected credit exposure (ECE) = expected value of the replacement value on the target date, if positive
   a. $ECE = \int_{-\infty}^{+\infty} \max(x,0) f(x) dx$
4. Worst credit exposure (WCE) = largest credit exposure over the horizon at some defined confidence level

**B.** Evaluation of CE must consider things like exposure limits, collateral, mark to market provisions and netting arrangements

**C.** Netting arrangements allow offsetting of the obligations under the same agreement

1. A standard part of the documentation of OTC derivatives
2. Net loss = $\max\left(\sum_{i=1}^{Nk} V_i, 0\right)$
3. Net replacement value (NRV) = $\sum_{k=1}^{K} netloss_k = \sum_{k=1}^{K}\left[\max\left(\sum_{i=1}^{Nk} V_i, 0\right)\right]$
4. NRV is the best measure of potential loss and is a very small fraction of notional amount
5. If NRV reflects changes in the potential changes over the horizon and diversification effects, it becomes comparable to bond equivalent exposure

## IV. Measuring Credit Risk

**A.** Pricing credit risk begins with measuring the distribution of expected credit losses over the life of the asset

1. Expected credit loss $ECL_t = ECE_t \times (1-f) \times prob(default)$
2. Present value of ECL, (PVECL) = $\sum_t \left[ECL_t \times (1-f) \times k_t\right] \times PV_t$
3. Table 18-6 in the text shows a numerical example of the computation of ECL

**B.** Portfolio credit risk

1. Distribution of credit related losses $L = \sum_{i=1}^{N} CE_i \times (1-f_i) \times b_i$
2. Simulation techniques are essential to adequately account for large numbers of assets, uncertain default and recovery rates and correlated defaults

**C.** Use of VAR as a measure of economic capital requires a long horizon and high confidence level
1. A 1-year horizon and 99.9% confidence level are commonly used and consistent with the Basel Committee requirements for tier 1 and tier 2 capital

**D.** Credit Risk Distribution
1. The expected credit losses are the average of the distribution of losses and should be covered by the credit reserve
2. The unexpected credit loss at a preselected confidence level is the economic capital that should be held in addition to the reserve
3. The latter is needed to cover losses beyond the expected loss

## V. Managing Credit Risk

**A.** Portfolio credit risk management requires measuring the expected net profit of each position and comparing it to the incremental contribution to risk. Incremental risk of a position is defined as the change in portfolio VAR when the position is eliminated from the portfolio

**B.** Figure 18-7 in the text shows and example of mapping positions by incremental risk and exposure size and establishing an efficient frontier as a boundary for acceptable tradeoffs
1. Using such optimization can reduce economic capital by 30% or more

**C.** Portfolio credit risk models have been developed to aid this process. Three well known models are KMV Moody's, Credit Manager and Credit Risk.
1. Table 18-8 in the text (not reproduced here) compares the main characteristics of the three and is worth reviewing
2. At a 99.85% confidence level the three models show the sum of expected loss and economic capital between 6% and 8%

**D.** Regulatory capital under Basel I of 8% is based on similar results. Basel II utilizes a more complex internal rating-based (IRB) approach
1. Under IRB approach, banks can provide inputs for PD, LGD and EAD and are used to compute risk weights and credit risk charges
2. Basel II still does not adequately consider correlation and diversification effects in portfolios
3. The extent of the tails of the loss distribution are heavily impacted by default correlations among assets

## VI. Conclusions

**A.** As regulators gain more comfort with banks internal credit models it is hoped that the next iteration of Basel rules will utilize the internal models allowing banks to align their economic capital with the regulatory capital

**B.** This should allow more efficient management and use of capital

**C.** While internal models are still evolving, verification of the models is still challenging
1. Longer time horizons make back testing more difficult
2. Default correlations are also difficult to validate with historical data

## Model Governance

Reviewer's note: *This is a new resource for 2018. It provides guidance on model governance (including PBR models) derived from the practices employed by a range of actuaries in industry, regulatory community and supporting organizations.*

### I. Model

A. ASOP definition of a model: A simplified representation of relationships among the real world variables, entities or events using statistical, financial, economic, mathematical or scientific concepts and equations

B. Covers almost everything actuaries do, e.g. pricing models, ALM and cash flow testing models, life insurance illustrations, reserve computations, etc.

C. Model results often drive significant decisions taken by the company and inappropriate models or assumptions, or even bad model data can lead to erroneous decisions

### II. Model Development

**A.** Steps in model development

1. Define specifications for the model
2. Program the model
3. Test/validate the model
4. Approve model for implementation
5. Complete documentation and implement control procedures

**B.** Any model presentation should cover the following:

1. Conceptual framework of the model including theory, methodology, key assumptions and parameters
2. Purpose and appropriate uses of the model (and what it is not appropriate for)
3. Limitations of the model, including data, time constraints, etc.
4. Calculations and programing code for internal models, and if available, external models
5. Governance and control procedures, including:
    a. Roles and responsibilities of personnel involved
    b. Documentation and data access controls
    c. Change control procedures, including authority, review and testing processes
    d. Model review and validation process
    e. Model review sign-offs

### III. Model Governance Policy and Standards applicable to actuaries

A. Both, the enterprise policy and standards, as well as the professional standards of practice promulgated by the ASB, apply to actuaries involved in modeling

## IV. Model Risk

A. ASOP definition: The risk of adverse consequences resulting from reliance on a model that does not adequately represent that which is being modeled, or that is misused or misinterpreted

B. A model risk profile should be developed that evaluates each significant model risk and can be used to develop an aggregate model risk score for use in guiding review and improvement priorities

C. Key model risk characteristics include:

1. Financial, regulatory, reputational and operational impact
2. Complexity of the data and assumptions
3. Complexity of the calculation engine
4. Intuitiveness/transparency of the model and overall complexity of the process
5. Experience/expertise of the developers and users

D. Model risk scoring is judgmental by its very nature

E. A comprehensive model governance policy should include the frequency of updates to model risk profile and ranking and may require more frequent updates for the higher risk models

## V. Model Governance

A. Good governance requires a clear definition of roles and responsibilities including:

1. Management and oversight of the model governance policy and procedures
2. Development, validation and documentation of models
3. Risk assessment of models and review/validation appropriate for the degree of risk
4. Model change management and update processes
5. Peer review of models

B. A designated model steward can provide a separation of responsibilities between model developers/owners and model approval, testing, quality assurance and production environments

C. Centralized vs. de-centralized governance framework

1. Centralized model governance allows use of resources specialized in model management
2. Decentralized model governance avoids the need to transfer model knowledge from owners to central unit

D. Model control can be improved by deploying the “three lines of defense model” of governance

1. The first line in in the operating and business units
2. The second line is the centralized model management and quality assurance functions
3. The third line is internal audit, external audit and regulators who provide independent oversight of controls

## VI. Model Processes and Controls

**A.** Processes to ensure sound development of assumptions and ensure model inputs are accurate, complete and consistent:

1. Strong controls around the development, approval and input of assumptions into models reduces model risk
2. A centralized repository for model assumptions aids the control and consistent use across all models
3. Establishing expectations of results before an update provides a basis for validation
4. Additional procedures include inventory control, back testing, visual inspection, attribution and waterfall analysis
5. Automated data input and verification procedures, and peer reviews provide additional controls
6. Spreadsheets utilizing the output of models also need controls to assure accuracy

## VII. Model Validation

A. Definition: Model validation involves an independent assessment of the reasonableness and adequacy of the model to assure that:

1. It is appropriate for the purpose
2. Is performing as expected across a range of scenarios
3. Is consistent with other internal and external models
4. Is in line with objectives, regulations, enterprise standards, ASOP's and industry practice

B. Riskier models require more robust and frequent validations than less risky models

C. Specialized models like economic scenario generators and regression based predictive models may have their own unique validation tests

D. Some companies embed validation in the modeling process, while others rely on separate (extensive) validations performed periodically

E. Can classify models by degree of riskiness, type (cash flow or regression), purpose (valuation, pricing, etc.), line of business, accounting type, and use this classification to guide the timing and frequency of validations

F. Examples of reviews and testing procedures:

1. Does the model fit its purpose?
2. Are the methods and procedures appropriate, compliant and consistent with industry and enterprise standards?
3. Is the data accurate, timely, complete and credible?
4. Are the assumptions appropriate, consistent with internal and external standards and correctly loaded?
5. How do model results compare with expectations and other similar models? Are they stable under a range of scenarios?
6. Are the model results useful and understood by users?
7. Is there adequate model governance and documentation?

G. A model validation plan would specify the person responsible, the timing and scope of validation

H. A validation report would include the overall assessment and highlight the key assumptions, limitations and improvement opportunities

## VIII. Model Documentation

A. Level of detail in model documentation should depend on the level of risk and the audience for which it is intended, with layers of detail needed for different users of the documentation

B. Documentation should include:

1. Model description and its intended purpose
2. Process maps including key controls and data handoff points
3. Update processes
4. Assumptions and methodologies
5. Limitations and risks not modeled
6. Approximations and shortcuts
7. Vendor or third party documentation
8. Data output and reports

## IX. Principle-based Reserve Model Governance Considerations

A. PBR models include stochastic and deterministic reserve models

B. Since PBR models may be part of the valuation process, they may be subject to a more rigorous standard of governance, controls, automation and documentation

C. *The paper lists various sections of the Valuation Manual and ASOP's (including ASOP's still in exposure draft stage) that apply to model governance. The list is not reproduced here but is worth a review to see the breadth of guidance already existing in an area that is still evolving.*

## Importance of Climate-Related Risks for Actuaries

Reviewer's note: *This is a new resource for 2021. It is focused on climate-related risks and the considerations actuaries should take account of in their performance of their duties and their role as advisors within and beyond the insurance industry.*

### I. Introduction

A. Importance and key evidence
   1. Climate change (CC) risks are increasing in significance in both likelihood and impact
   2. Failure to address them can quickly take regional crises to a global scale
   3. CC events include windstorms, floods, droughts and wild fires
   4. CC risks can impact health, morbidity, mortality, longevity and the value of assets

B. Roles for actuaries to play in evaluating CC risks
   1. Review the risk models for continued suitability in light of evolving CC risks
   2. Create products and pricing structures to respond to the CC environment
   3. Assure that product design meets the needs of all stakeholders including customers, regulators and shareholders
   4. Advise investment managers, pension funds and insurers on CC risks related to evaluation of investments and on ESG (environmental, social and governance) considerations in investing
   5. Contributing to the public debate about CC and advising governments and other public bodies about aspects of CC risks

C. Current initiatives within the actuarial community
   1. CAS and SOA joint task force creates and maintains an Actuaries Climate Index
   2. IAA Resource and Environment Working Group develops papers on relevant issues
   3. Major actuarial journals publish relevant articles periodically

### II. Climate related risks

A. Physical risks
   1. Can be acute (event-driven) or chronic (longer-term)
   2. May have financial implications e.g., direct damage to assets or indirect impacts such as supply chain disruptions
      a. Asset values and returns reduced by the costs of CC adaptation
      b. Increased mortality, morbidity, infrastructure damage and business interruption
      c. Frequency of extreme weather events leading to effects like insect infestation, flooding, crop damage, wildfires, etc.
      d. Disruption of health and social services leading to forced migration, etc.

B. Transition risks
   1. Policy risk:
      a. Actions to constrain climate harming activities
      b. Actions to promote adaptation to CC
   2. Technology risk: Transition to a low-carbon/energy efficient system will produce winners and losers
   3. Market Risk: CC may result in changes in supply or demand for some commodities, products or services

C. Legal and Reputation risks
   1. Legal risk: Increased litigation due to:
      a. Failure to mitigate impact of CC
      b. Failure to adapt to CC
      c. Insufficient disclosure of material financial risk due to CC
   2. Reputation risk: Attributable to changing consumer or community perceptions of an organization

## III. Actuarial Modeling

A. Actuarial considerations include:
   1. CC related changes in the frequency and severity of losses
   2. Limited technical knowledge on how to model future climate scenarios
   3. Limited data and greater uncertainty around data trends
   4. Widely differing impacts of events by geography, segment, etc.
   5. Future scenarios may differ materially from past experience

B. Investment assumptions
   1. Impact of CC risks on investments can be categorized into physical, transition and legal/reputation risks
   2. ESG-driven investment strategies are becoming more common

C. Mortality and morbidity assumptions (long-term impact could be more significant than current)
   1. CC impact on food production and distribution could lead to food insecurity and water shortages
   2. Rising temperatures may benefit some cold regions at the detriment of temperate and warm regions
   3. Pandemics and vector-borne diseases may become more potent and prevalent
   4. Rising social unrest, migration, etc. may lead to demands for governmental intervention

D. General Insurance claims assumptions
   1. Changes in the frequency and severity of catastrophic events may be difficult to identify in advance and to measure as they occur
   2. Examples of CC risk considerations include:
      a. Pricing and coverages of agricultural products may need to change
      b. Decarbonization of the economy will create new opportunities as well as risks to current exposures
      c. CC related liability risk coverage will require careful design and pricing
      d. Current catastrophe coverages may need to change to reflect the trends in frequency, severity and impact
   3. Modeling of CC related risks over long periods will remain challenging

## IV. Product Management

A. Proper design and repricing of existing products in light of CC risks Is an immediate challenge
B. Greater granularity in pricing improves accuracy at the cost of risk pooling and its social benefits
C. Investment managers implementing ESG approaches must choose between engaging with companies or divesting
D. There will be opportunities to create new products that meet customer needs and promote better CC outcomes

## V. Risk and Capital Management

A. ERM frameworks
   1. CC risks impact on the various risk classes can be scored as illustrated in the example in Table 1 (not reproduced here) in the text
   2. Table 2 in the paper (also not reproduced here) summaries the various aspects of the ERM framework that need to include consideration of CC risks
   3. The insurer's board of directors should also the effect of CC risks on the organization
   4. Insurers are increasingly required to reflect CC risks in their ORSA filing

B. Capital adequacy
   1. Models can be used to explore potential vulnerabilities
   2. Thorough scenario analysis is essential given range of potential outcomes, including stress tests, to determine adequate mitigation strategies
   3. Rating agencies may include CC related risk measures in their assessment

## VI. Investment management

A. For pension funds, the most significant risk is a potential decline in the value of assets
B. Actuaries can provide valuable assessment of CC risk and advice on investment strategies to pension fund management
C. Pension funds are having to address the growing demand for ESG investment management
D. Actuaries an also actively participate in the implementing of investment strategy
   1. Evaluating the CC vulnerabilities of individual securities
   2. Calculating CC risk measures such as carbon footprint
   3. Reporting on the CC exposure of the portfolio
   4. Development of products that allow for CC risks

## VII. Disclosure

1. Actuaries may be asked to support development of the risk disclosures in financial statements and regulatory filings
2. In 2017 the TCFD published its recommendations
   a. Governance: Disclose the governance around CC risks
   b. Strategy: Disclose the actual and potential impact of CC risks on the strategy and financial planning
   c. Risk Management: How the organization identifies, assesses and manages CC risks
   d. Metrics and targets: Disclosure of metrics used to manage CC risks

## VIII. Implications for

A. Actuaries will need to collaborate with regulators, business leaders and other stakeholders to understand the economic impacts of CC risks and to develop mitigation and adaptation strategies

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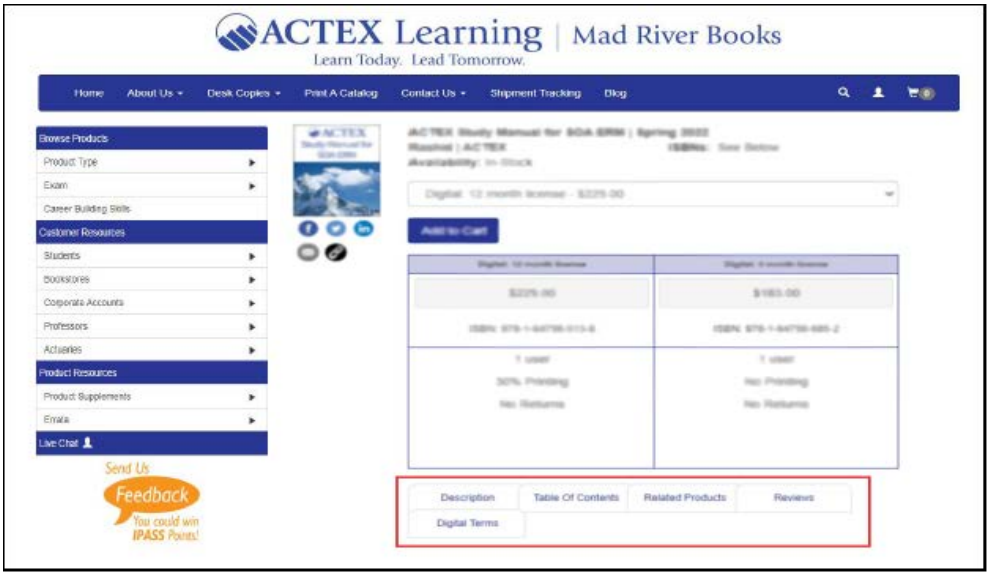


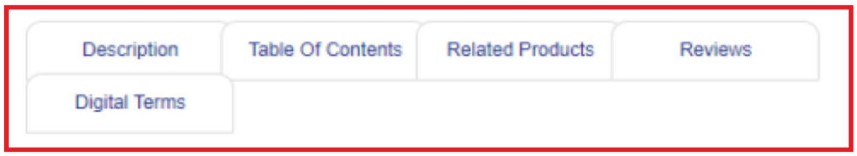


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